The distribution of selenium in stream sediments and soils in the Humboldt River basin and surrounding area In 1995, the U.S. Bureau of Land Management identified selenium along with 12 other elements to investigate within the Humboldt River basin located in northern Nevada. These elements are important because of their role as pathfinder elements for mineral deposits or as potential toxins in the environment. This report is one of the 13 separate published reports (MF-2407-A-M) that integrate the results of two geochemical studies conducted by the Figure 3. Overlapping histograms of log-U.S. Geological Survey and that present geochemical maps created using computer models transformed selenium values. Humboldt River basin of stream-sediment and soil geochemistry. The in blue and Winnemucca-Surprise in yellow, and other 12 reports present geochemical maps for Ag, where there is overlap, the histograms are green. As, Au, Ce, Co, Cu, Fe, Ni, Pb, Sb, Sc, and Zn. These geochemical maps provide a visual aid to Selenium (Se) has been identified as an element interpreting the trends and anomalies in element of interest because of its association as a pathfinder concentration when combined with information element for ore deposits and for potential toxicity to wildlife within the Humboldt River basin. It is about the geology, topography, and mining districts in the Humboldt River basin. considered an essential nutrient; however, The Humboldt River basin is a naturally occurring, deficiencies and excesses can cause adverse health internally draining river basin that covers effects in humans, wildlife, plants, and especially approximately 43,700 km<sup>2</sup> (16,900 mi<sup>2</sup>) and forms a freshwater biota (Eisler, 1985). Globally, the concentration of selenium in substantial part of the larger Great Basin. The Humboldt River basin includes the upper reaches of magmatic rocks range from 0.01 to 0.05 ppm, and are highest in shale and argillaceous sediments (0.4 the Little Humboldt River in Elko County, the Reese River in Lander County, and the main Humboldt to 0.6 ppm) and sandstone and carbonate (0.03 to 0.1 ppm) rocks. Selenium concentrations in the River and its many tributaries that flow ultimately westward into the Humboldt Sink. Figure 1 shows Humboldt River basin range from <0.001 to 60.5 ppm. Selenium forms selenides (Se<sup>2-</sup>), selenates the map area and the Humboldt River basin. Stream-sediment and soil samples originally (SeO<sub>4</sub>), and selenites (SeO<sub>3</sub>) when oxidized and collected for the NURE (National Uranium may substitute for small quantities of sulfur in Resource Evaluation) program were reanalyzed in sulfide minerals. Selenium tends to occur in trace 1996 for the mineral and environmental assessment amounts with As, Sb, Cu, Ag, and Au in sulfide of the Humboldt River basin (4,336 samples; Folger, deposits, black shale, and carbonaceous sandstone 2000) (fig. 2). An additional 73 stream-sediment samples originally collected for the Winnemucca-Construction of thematic maps Surprise mineral resource assessment (King and The thematic map is a useful format for representing others, 1996) were reanalyzed by Folger (2000) for the regional variation in geochemical concentration total selenium. The combined sample coverage is generally spatially uniform with a sample density of between samples. The approach used for each data one sample site per 17 km<sup>2</sup>. Sample density is set was to (a) transform every concentration to the greatest along range fronts and sparsest along logarithm of the concentration for the element and mountain ridges and broad valley bottoms. (b) calculate the mean and standard deviation of the log-transformed data. Element concentrations are now expressed as a logarithm and are classified by standard deviations above or below the mean. The standard deviation category for each sample is indicated by a color symbol. Samples with standard deviations below the mean were assigned the "cool" hues of blues and greens, and samples with standard deviations above the mean were assigned the "warm" hues of gold, orange, and red. A small geochemistry map (fig. 4) was generated from the data using a Geosoft software version of the minimum-curvature algorithm. The minimumcurvature algorithm (Briggs, 1974; Webring, 1981) is useful in fitting a surface to closely spaced and gradually varying data while interpolating smoothly Figure 2. Sample localities of NURE samples between widely spaced data. Data gaps, while reanalyzed by ICP-AES (red) and HAAS (green) conservatively interpolated, may occasionally allow methods for the Humboldt River basin mineral and the surface to overshoot or undershoot. Contour environmental assessment. intervals on the thematic map are calculated from the minimum curvature grid values and provide an indicator of the generalized spatial continuity of The  $-80 (<180 \mu m)$  or  $-100 (<150 \mu m)$  sieve mesh geochemical trends. Contour lines (in brown) left unclosed reflect the sparseness of data available in grain-size fractions of stream-sediment and soil samples were selected for reanalysis. The samples were prepared and analyzed using a weak acid digestion and organic extraction prior to analysis by Briggs, Ian C., 1974, Machine contouring using inductively coupled plasma-atomic adsorption spectrometry (ICP-AES) (Motooka, 1996). This minimum curvature: Geophysics, v. 39, no. 1, p. digestion method cannot dissolve complex silicates Eisler, R., 1985, Selenium hazards to fish, wildlife, and therefore may underestimate the total selenium present in the sample. However, the method does and invertebrates: a synoptic review: U.S. Fish and permit measurement at low detection levels. Wildlife Service, Biological Report 85(1.5) Base from U.S. Geological Survey, 1965 Contaminant Hazard Reviews Report No.5, 57 p. Samples in the western part of the Humboldt River Lambert Conformal Conic Projection based on standard parallels 33° and 45° Folger, H.W., 2000, Analytical results and sample basin (green symbols in fig. 2) were analyzed by hydride-generation atomic adsorption (Hageman and locations of reanalyzed NURE stream-sediment and Welsch, 1996). There were 681 and 769 qualified soil samples for the Humboldt River basin Mineral-Environmental Resource Assessment, northern values (below the limit of detection) in the western Nevada: U.S. Geological Survey Open-File Report Humboldt River basin (green) and the eastern Humboldt River basin (red), respectively. The 00-421, 491 p. Hageman, P.L., and Welsch, E., 1996, Arsenic, Humboldt River basin-west dataset is a subset of antimony, and selenium by flow injection or Winnemucca-Surprise samples that were reanalyzed continuous flow-hydride generation-atomic for selenium and thallium concentrations during the absorption spectrophotometry, in Arbogast, B.F., ed., Humboldt River basin study (Folger, 2000). Prior to computing the statistics and subsequent grids, all Analytical methods manual for the Mineral Resource Surveys Program, U.S. Geological qualified values were replaced with a value equal to Survey: U.S. Geological Survey Open-File Report 0.0001. Table 1 contains the statistical profile and lower limits of determination (LLD) of the two 96-525, p. 24-30. King, H.D., Fey, D.L., Matooka, J.M., Knight, R.J. datasets. Figure 3 shows the lognormal distribution Roushey, B.H., and McGuire, D.J., 1996, of the data. The histograms illustrate the overwhelming effect of qualified values (tallest Analytical data and sample locality map of stream-**EXPLANATION** yellow bar on left) on the distribution statistics in the sediment and soil samples from the Winnemucca-Surprise Resource Area, northwest Nevada and log value (ppm Se) Winnemucca-Surprise study. To enhance the northeast California: U.S. Geological Survey Open-Winnemucca-Surprise dataset continuity of data, the two datasets were combined File Report 96-062-A (paper) and 96-062-B into a single dataset and plotted on the thematic [Mean log value is -1.515; (diskette), 341 p. geometric mean ppm Se is 0.03] Motooka, Jerry, 1996, Organometallic halide Table 1. Statistics for selenium. LLD, lower limit of extraction for 10 elements by inductively coupled • 1.665 to 3.255 (> 46.2) determination; N, number; Dev, deviation. plasma-atomic emission spectrometry, in Arbogast, Humboldt River basin Humboldt River basin-west Combined datasets B.F., ed., Quality assurance manual for the Branch • 0.075 to 1.665 (1.20 to 46.2) of Geochemistry: U.S. Geological Survey Open-File Report 96-525, p 102-109. -1.515 to 0.075 (0.03 to 1.20) Neal, R.H., 1995, Selenium, in Alloway, B.J., ed Heavy metals in soils, Second edition, Blackie -3.105 to -1.515 (0.001 to 0.03) Academic and Professional, p. 260-283. Webring, Michael, 1981, MINC: A gridding program Figure 1. Index map of study area. • -4.695 to -3.105 (<0.001) based on minimum curvature: U.S. Geological Survey Open-File Report 81-1224, 41 p. Figure 4. Continuous surface model of Se analyses. — — Humboldt River basin boundary Acknowledgments We wish to thank Karen Kelley, Steven Smith, and — 0.6 (ppm Se) contour interval Craig Brunstein (U.S. Geological Survey) for their reviews of this report. 1.8 (ppm Se) contour interval Manuscript approved for publication September 23, 2002 10 0 descriptive purposes only and does not imply endorsement by the U.S. Geological Survey For sale by U.S. Geological Survey Information Services Box 25286, Federal Center, Denver, CO 80225 This map was produced on request, directly from digital files, on an electronic plotter. It is also

Map Showing Selenium Concentrations from Stream Sediments and Soils Throughout the Humboldt River Basin and Surrounding Areas, Northern Nevada

available as a PDF file at http://geology.cr.usgs.gov